Clinical Practice Guideline

Infarction-Related Cardiogenic Shock—Diagnosis, Monitoring and Therapy

A German-Austrian S3 Guideline

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*Guideline group see *eBox 1*

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Summary

Background: The second edition of the German-Austrian S3 guideline contains updated evidence-based recommendations for the treatment of patients with infarction-related cardiogenic shock (ICS), whose mortality is several times higher than that of patients with a hemodynamically stable myocardial infarction (1).

Methods: In five consensus conferences, the experts developed 95 recommendations—including two statements—and seven algorithms with concrete instructions.

Results: Recanalization of the coronary vessel whose occlusion led to the infarction is crucial for the survival of patients with ICS. The recommended method of choice is primary percutaneous coronary intervention (pPCI) with the implantation of a drug-eluting stent (DES). If multiple coronary vessels are diseased, only the infarct artery (the "culprit lesion") should be stented at first. For cardiovascular pharmacotherapy—primarily with dobutamine and norepinephrine—the recommended hemodynamic target range for mean arterial blood pressure is 65–75 mmHg, with a cardiac index (CI) above 2.2 L/min/m^2. For optimal treatment in intensive care, recommendations are given regarding the type of ventilation (invasive rather than non-invasive, lung-protective), nutrition (no nutritional intake in uncontrolled shock, no glutamine supplementation), thromboembolism prophylaxis (intravenous heparin rather than subcutaneous prophylaxis), und further topics. In case of pump failure, an intra-aortic balloon pump is not recommended; temporary mechanical support systems (Impella pumps, veno-arterial extracorporeal membrane oxygenation [VA-ECMO], and others) are hemodynamically more effective, but have not yet been convincingly shown to improve survival.

Conclusion: Combined cardiological and intensive-care treatment is crucial for the survival of patients with ICS. Coronary treatment for ICS seems to have little potential for further improvement, while intensive-care methods can still be optimized.

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In the German FITT-STEMI trial on 12 675 patients with ST segment elevation myocardial infarction (STEMI) who were treated with percutaneous coronary intervention (PCI) following emergency medical service transportation to hospital, mortality among hemodynamically stable myocardial infarction (MI) patients (85%) and non-resuscitated MI patients with infarction-related cardiogenic shock (ICS) (5.5%) was 2.7% and 39%, respectively (1). Successful coronary revascularization alone does not seem to ensure a favorable outcome in ICS patients, since the primary factor responsible for their unfavorable prognosis is the shock-related dramatic drop in perfusion of vital organs and the subsequent development of multiple organ dysfunction syndrome (MODS), even after revascularization of the infarction-related coronary artery. Hence, ICS patients require not only interventional cardiology care as in uncomplicated myocardial infarction, but also optimum intensive care treatment.

In light of the complexity of the condition, the first ICS-specific guideline was developed (2). In the now available updated second edition of this guideline, these two components of the management of ICS—cardiology and intensive care treatment—are given adequate consideration; in contrast, the European ICS recommendations (3), which have recently been published, largely focus on the cardiological aspects.

Since only few of the recommendations are supported by high-quality data from randomized

controlled trials (RCTs) on ICS patients, it was necessary to review the evidence for critically ill patients and for patients with myocardial infarction in respect to its applicability to ICS patients and, if applicable, to use these findings to make expert-consensus recommendations.

The 95 recommendations (including two statements) and seven algorithms enable clinicians to treat their ICS patients in the prehospital setting, in the cardiac catheterization laboratory, in the intensive care unit, and in the rehabilitation clinic based on the currently available evidence.

Methods

Guideline design and development

The recommendations of the guideline group (*eBox 1*) were developed in five sessions, using nominal group processes; details are provided in the guideline report (4). The guideline is valid until 31 January 2024.

The aim of the guideline and who the guideline is for

The aim of this S3 guideline is to implement evidence-based recommendations on best quality of care for patients with ICS. The guideline is for all clinicians responsible for treating patients with myocardial infarction and cardiogenic shock, mainly cardiologists, internists, intensive care physicians, cardiac surgeons, anesthesiologists, physicians in emergency departments and chest pain units, emergency physicians, and rehabilitation physicians. Specific guideline information is also relevant for nursing staff.

Data acquisition

For the second edition of the guideline, again a primary literature search (PubMed, search terms: "myocardial infarction and cardiogenic shock") was conducted, covering the period following the literature search for the first edition (until 30 September 2009) from 1 October 2009 to 31 January 2019 (3668 hits) (*eFigure)*. For the supporting text, publications from 2019–2021 known to the guideline group were also used; however, these papers did not influence the consensus recommendations.

Grades of recommendation

The grades of recommendations are detailed in *Box 1.*

BOX 1

Grades of recommendation

- **Strong recommendation/strong negative recommendation**
  ↑↑ / ↓↓ "shall"/"shall not"
  >90% of patients would decide for it/against it or benefit/not benefit from it or even be harmed by it.
- **Recommendation/negative recommendation**
  ↑ / ↓ "should"/"should not"
  About 60% of patients would decide for it/against it or benefit/not benefit from it or even be harmed by it.
- **Recommendation open**
  ↔ "may"
  No conclusive study results are available to proof a beneficial or harmful effect.

Results

Box 2 shows selected recommendations. In particular, new and modified recommendations of the updated guideline are presented below (*Box 3*).

Initial management

Every minute counts! In no other group of patients with myocardial infarction, the length of time between diagnosis and PCI is as critical for patient survival as it is in the ICS patient group (1). Therefore, the emergency physician must establish the suspected diagnosis of "ICS" quickly in the prehospital setting (↑↑): the diagnosis "myocardial infarction" (ST/non-ST segment elevation myocardial infarction[STEMI/NSTEMI]) based on clinical presentation, ECG and, in the further course, laboratory results; the diagnosis "shock" typically based on systolic blood pressure (BPsys) <90 mm Hg sustained for 30 min in conjunction with signs of reduced organ perfusion (cold extremities, oliguria, mental alterations). Invasively established shock criteria (cardiac index [CI] <2.2 L/min/m^2, pulmonary artery occlusion pressure [PAOP] >15 mm Hg) are not required for diagnosis.

Revascularization

Rapid restoration of interrupted coronary blood flow in the infarction-related artery is critical for prognosis (↑↑)— whenever possible by means of primary percutaneous coronary intervention (pPCI) and implantation of a drug-eluting stent (DES) (↑)—in case of initial ICS within 90 min (↑) and in case of delayed occurrence of ICS as early as possible (↑↑)—;in few selected cases by means of coronary artery bypass graft surgery (CABG) and, if pPCI is not available in time, by means of systemic fibrinolysis.

The superiority of the invasive strategy (mainly pPCI) was established in the SHOCK trial published 20 years ago and improvements in long-term survival of 20% have been shown in RCTs (relative risk 0.82; 95% confidence interval [0.69; 0.97]) (5). A significant reduction in hospital mortality was shown by a propensity registry, both in STEMI-ICS patients (odds ratio [OR]: 0.37 [0.34; 0.40], p <0.0001) and in NSTEMI-ICS patients (OR 0.47 [0.43; 0.51], p<0.0001) (6).

In patients with multivessel coronary artery disease, only the infarction-related coronary artery

BOX 2

Selection of recommendations*1 of the German-Austrian S3 guideline "Infarction-related Cardiogenic Shock—Diagnosis, Monitoring and Therapy", focusing on new or revised recommendations

- **Coronary reperfusion**

  Culprit lesion-only versus multivessel pPCI (evidence*2: 1^{++}) {eLV 5.2.4.A.}*3

  ↑↑ In ICS patients with multivessel coronary artery disease and multiple relevant stenoses (>70%), only the culprit lesion "shall" be treated during acute revascularization.

- **The ICS patient after cardiac arrest**

  Revascularization therapy (evidence*2: EC) {eLV 8.3.4.A.}*3

  ↑ If cardiac arrest is immediately reversed by defibrillation, early CC and, if indicated, pPCI "should" be considered in ICS patients after benefit-risk assessment on a case-by-case basis.

- **Monitoring**

  Measuring cardiac output (evidence*2: EC) {eLV 4.6.4.A.}*3

  ↑↑ In every patient with persistent infarction-related cardiogenic shock, the cardiac output "shall" be monitored as soon as possible to guide further treatment.

- **Intra-aortic balloon pump (IABP) and temporary mechanical circulatory support (TMCS) devices**

  No IABP with pPCI (evidence*2: 1^{++}) {eLV 7.3.7.A.}*3

  ↓ In patients with ICS due to pump failure, an IABP "should not" be implanted along with primary PCI.

  Temporary mechanical circulatory support device (pVAD, VA-ECMO/ECLS) (evidence*2: EC) {eLV 7.6.A.}*3

  ↔ In ICS patients who cannot be stabilized over time, a TMCS device "may" be implanted if a realistic treatment goal is pursued and the following requirements are met: implantation without delaying revascularization; documented realistic treatment goal, evaluated in the cardiac care team; link to/collaboration with a cardiac center to ensure early destination therapy; implantation before irreversible organ damage has occurred; enrollment in a TMCS registry of a medical society.

- **Organ dysfunction: Lungs**

  Invasive ventilation (evidence*2: EC) {eLV 9.1.3A.}*3

  ↑ Intubation and invasive ventilation "should" be given preference to noninvasive ventilation in patients with ICS.

  Lung-protective ventilation (evidence*2: EC) {eLV 9.1.5.A.}*3

  ↑ After hemodynamic stabilization, ventilation "should" be performed according to the criteria of lung-protective ventilation (peak pressure/maximum plateau pressure ≤ 30 mbar, V_T 6–8 mL × kg^{-1} predictive BW*4, PEEP 5–15 mbar), if cardiac function permits.

  Oxygenation (evidence*2: EC) {eLV 9.1.4.A.}*3

  ↑↑ Since hemodynamic instability is the primary concern in patients with cardiogenic shock, the ventilation pattern "shall" be selected in a way that adequate oxygenation (SaO_2 94–98%) is achieved with the least possible negative hemodynamic impact and without delaying revascularization.

- **Nutrition**

  Nutrition support stop in uncontrolled shock (evidence*2: EC) {eLV 10.1.1.A.}*3

  ↓ In patients with uncontrolled ICS, enteral nutrition "should not" be administered before control of the shock is achieved by administration of fluid and vasopressors/inotropes.

  No glutamine supplementation (evidence*2: EC) {eLV 10.1.1.D.}*3

  ↓ In both enteral and parenteral nutrition therapy, supplementation of glutamine "should" be avoided.

- **Transfusion strategy**

  Red blood cell transfusion (evidence*2: EC) {eLV 10.2.5.A.}*3

  ↑ In patients <65 years with ICS, packed red blood cells "should" be transfused:
  – if Hb concentration below 7.0 g × dL^{-1} / 4.3 mmol × L^{-1}
  – or hematocrit below 25%.

  ↑ Target values in patients <65 years "should" be:
  – Hb concentration 7.0–9.0 g × dL^{-1} /4.3–5.6 mmol × L^{-1}
  – or hematocrit of ≥ 25 %.

  ↑ In older (age ≥ 65 years) patients, a hematocrit decrease to levels below 30% "should" be avoided.

- **Prophylactic measures: prophylaxis of deep venous thrombosis and pulmonary embolism**

  Thromboprophylaxis not subcutaneously (evidence*2: EC) {eLV 10.4.1.B.}*3

  ↓ In light of the unpredictability of subcutaneous drug absorption, the heparin to be administered "should not" be administered subcutaneously, at least not during the acute shock period.

- **Prophylactic measures: Stress ulcer prophylaxis**

  Stress ulcer prophylaxis (evidence*2: EC) {eLV 10.4.2.A.}*3

  ↑↑ ICS patients "shall" receive stress ulcer prophylaxis.

- **Aftercare and rehabilitation**

  Rehabilitation (evidence*2: EC) {eLV 11.2.3.A.}*3

  ↑↑ All patients with status post ICS "shall" be offered a rehabilitation program.

*1 Grades of recommendation (arrow symbols) see Box 1 "Grades of recommendation"
*2 Levels of evidence 1^{++} = high-quality systematic reviews of randomized controlled trials (RCTs) or RCTs with low risk of bias; for further details, including levels of evidence, see guideline report in (4)
*3 „{}" Numbering of the respective guideline recommendation in the electronic long version (eLV) (4)
*4 Predicted body weight:
50 (men) and 45.5 (women) + 0.91 (height (cm) – 152.4)

ECLS, extracorporeal life support; EC, expert consensus see guideline report in (4); CC, cardiac catheterization; CO, cardiac output;
ICS, infarction-related cardiogenic shock; IABP, intra-aortic balloon pump;
PCI, percutaneous coronary intervention; PEEP, positive end-expiratory pressure;
pPCI, primary percutaneous coronary intervention;
pVAD, percutaneous ventricular assist device;
SaO_2, arterial oxygen saturation; TMCS, temporary mechanical circulatory support;
VA-ECMO, venoarterial extracorporeal membrane oxygenation;
V_T, tidal volume.

("culprit lesion") shall be dilated in the acute stage (*Box 2*, ↑↑), with a 16% lower 30-day mortality compared to multivessel PCI (7).

In patients with complex coronary pathology, immediate revascularization shall be sought in consultation with cardiologists and cardiac surgeons, either as pPCI or as CABG and in case of unsuccessfully attempted pPCI as CABG (↑↑). Mortality of acute CABG is reported to be not higher than mortality of pPCI (8).

The further pPCI procedure in patients with ICS (vascular access, co-medication, same level of success in men and women as well as in diabetic patients) follows the procedure for patients with STEMI/NSTEMI. Likewise, in patients aged >75 years, early revascularization should be considered based on an individual evaluation of positive components, such as mobility, autonomy and social integration, as well as negative components, such as frailty, immobility and need of nursing care (↑). An increase in mortality of 32% in ICS patients aged <65 years to 56% in patients >85 years was reported in the absence of a higher rate of bleeding complications (9).

Resuscitation in patients with infarction-related cardiogenic shock

One in two ICS patients initially experiences cardiac arrest (7, 10). Successfully resuscitated ICS patients show an increase in mortality by about 20% compared to ICS patients without cardiac arrest (11). In these patients, too, early cardiac catheterization (CC)/pPCI should be considered based on an individual benefit-risk evaluation (*Box 2*, ↑); however, the decision for pPCI must be made without assessment of the neurological prognosis as this can only be performed later in the course of treatment.

Targeted temperature management (TTM) with lowering of body temperature to 32 – 36 °C for at least 24 hours is recommended for all resuscitated comatose ICS patients (↑). Until valid data is available, the decision on the use of extracorporeal cardiopulmonary resuscitation (eCPR) in ICS patients has to be made on an individual basis (12, 13).

Persistent shock after revascularization: monitoring and drug therapy

In patients with persistent signs and symptoms of shock after revascularization, the goals of hemodynamic treatment control (*Figure*) are: to stabilize blood pressure and to ensure adequate perfusion to vital organs. Here, it is recommended to repeatedly measure cardiac output (CO) (*Box 2*, ↑↑) with a target pressure-flow corridor *(Figure)*: "mean arterial pressure" (MAP) >65 to <75 mm Hg, and a cardiac index (CI) >2.2 L/min/m^2 or a cardiac power index (CPI; product of CI and MAP × 0.0022 in W/m^2) of >0.4, with low-dose catecholamine administration and a heart rate of <100/min with sinus rhythm and <110/min with atrial fibrillation.

BOX 3

Diagnosis, monitoring and therapy of infarction-related cardiogenic shock—alterations in the 2nd edition

- Primary coronary intervention (pPCI) with implantation of a drug-eluded stent is the method of choice for coronary revascularization.
- In multivessel coronary artery disease, culprit-lesion-only pPCI
- In shock due to pump failure, intra-aortic balloon pump not to be used
- In case of pump failure, a temporary mechanical circulatory support device (e.g. Impella pumps, venoarterial extracorporeal membrane oxygenation) may be used in selected patients under very strict precautions.
- Nutrition support stop in uncontrolled shock
- In patients with infarction-related cardiogenic shock, neither enteral nor parenteral glutamine supplementation

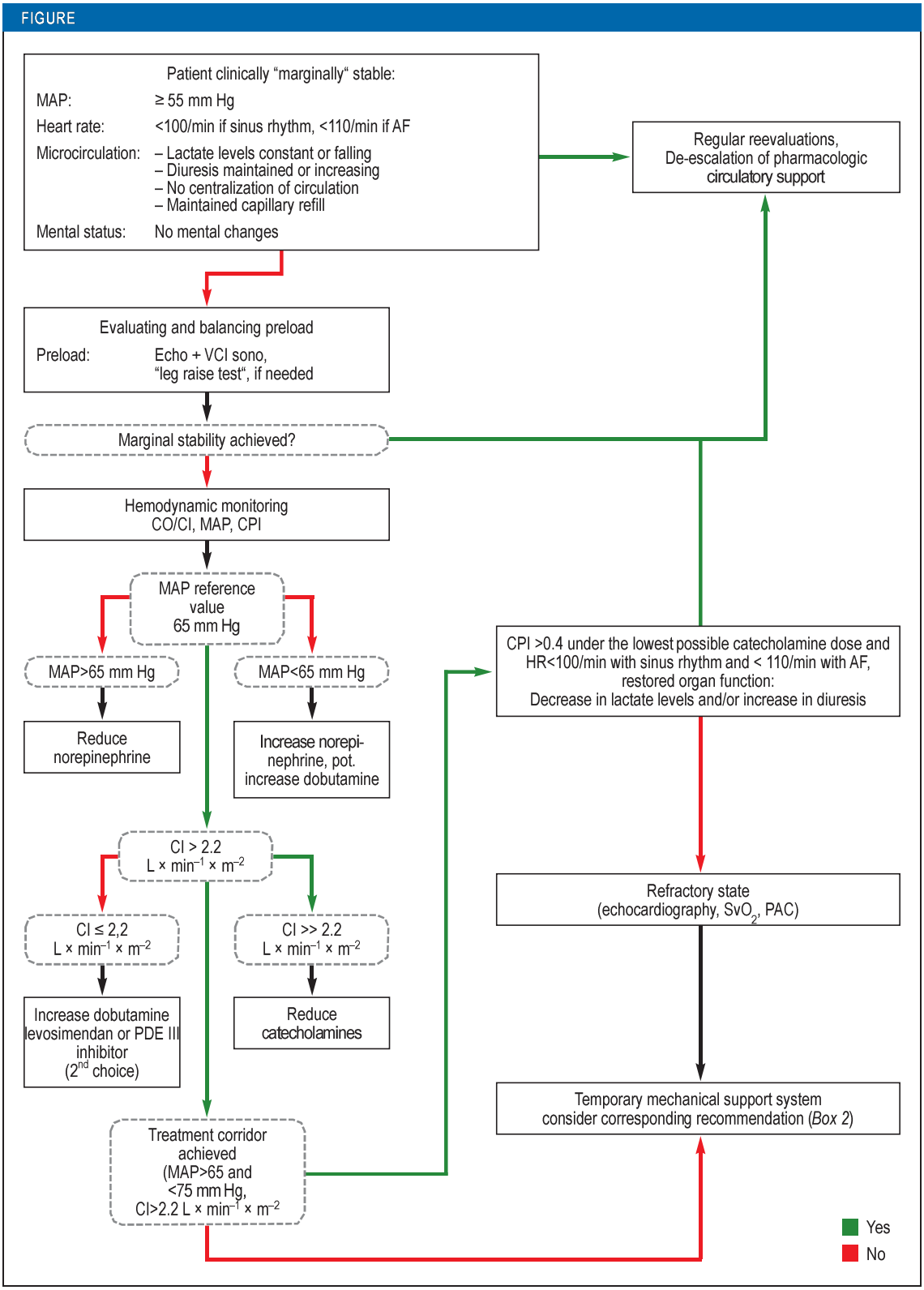
Furthermore, dobutamine is the inotropic agent of choice (↑) and, if MAP is <65 mm Hg, norepinephrine the vasopressor of choice (↑). In comparison to norepinephrine administration, lactate levels are higher with epinephrine administration in ICS patients and the rate of patients with refractory shock is increased (14). In patients refractory to catecholamines, levosimendan should be preferred over phosphodiesterase III inhibitors (↑). In light of potentially serious adverse events, caution is required with regard to catecholamine administration; especially in clinically "marginally" stable ICS patients *(Figure)*, catecholamine administration is not generally required.

Not convincing yet: mechanical cardiovascular support

Until a few years ago, the intra-aortic balloon pump (IABP) was part of the standard treatment armamentarium, with a class I recommendation in the European and US guidelines and an implantation frequency in Germany of about 10 000/year; however, its effectiveness was not proven in RCTs. The small randomized IABP-SHOCK study on 40 ICS patients was the first to provide evidence conflicting with this "standard" treatment strategy as it found that the use of IABP did neither result in an improvement of hemodynamics (no significant increase in CI) nor of MODS severity measured using the APACHE II score (15, 16). In the subsequent IABP-SHOCK II study on 600 ICS patients treated with pPCI (95.8%) in 37 centers in Germany, the use of IABP did neither reduce mortality after 30 days (39.7% [IABP] versus 41.3%; relative risk [RR]: 0.96 [0.79; 1.17], p = 0.69) (10) nor after 12 months, nor after six years. A subsequent Cochrane analysis (17)—seven studies with 790 ICS patients—did not show a mortality-reducing effect of IABP either.

Based on these results, an IABP should not be implanted in patients with ICS due to pump failure and

FIGURE



Hemodynamic shock therapy in patients with infarction-related cardiogenic shock

AF, atrial fibrillation;

CPI, cardiac power index;

CI, cardiac index;

HR, heart rate;

CO, cardiac output;

MAP, mean arterial pressure;

PAC, pulmonary artery catheter;

PDE III inhibitor, phosphodiesterase III inhibitor;

Sono, ultrasonography;

SvO_2, venous oxygen saturation;

VCI, vena cava inferior

PCI as the primary treatment. (*Box 2*, ↓). IABP may be used in patients who develop mechanical complications after myocardial infarction (↔).

Temporary mechanical circulatory support (TMCS) devices include percutaneous (left) ventricular assist devices (p[L]VAD), such as Impella pumps and TandemHeart, as well as venoarterial extracorporeal membrane oxygenation (VA-ECMO)/extracorporeal life support (ECLS). These TMCS devices achieve a cardiac output of up to 5 L/min and 7 L/min (pLVAD and ECLS, respectively). Despite the considerable increase in cardiac output, no reduction in mortality has yet been demonstrated for TMCS in registries and small meta-analyses, neither for pLVADs (18, 19) nor for ECLS (20. 21). Until results from meanwhile initiated RCTs are available, it is recommended that TMCS "may" be used under strict precautions (*Box 2*, ↔).

Mechanical MI complications—a task for the cardiac care team

ICS patients with shock due to mechanical MI complications (0.2–6.9%) (22) shall be treated by a cardiac care team consisting of a cardiac surgeon and a cardiologist with experience in intensive care medicine (↑↑). In patients with post-infarction ventricular septal defect and ICS, interventional (↑) (23) closure is a treatment option besides surgical repair (↑). In case of rupture of a free ventricular wall, immediate surgical repair shall be attempted (↑↑). In patients developing hemodynamically relevant acute mitral regurgitation, immediate surgical repair shall be performed (↑↑).

Management of organ dysfunction

The IABP-SHOCK study showed that in ICS patients a developing multiple organ dysfunction syndrome (MODS)—measured by APACHE II scoring—is a stronger predictor of mortality than the cardiac index (CI) (15). The guideline describes the treatment options for supporting the impaired function of the shock organs (lungs, kidneys, liver, gastrointestinal tract, endocrine system, nervous system, and brain).

Respiratory failure

In ICS patients requiring mechanical ventilation, invasive ventilation—arterial oxygen saturation (SaO_2) 94–98% (↑)—should be given preference over non-invasive ventilation (*Box 2,* ↑) (24). The reasons behind this recommendation include continuously stable ventilation conditions, relief from the breathing effort with large cardiac output portion and prevention of psychomotor agitation and exhaustion of ICS patients.

The benefits of lung-protective ventilation (maximum plateau pressure ≤ 30 mbar, tidal volume target (V_T) of 6–8 mL/kg predicted body weight [see legend in *Box 2*]; positive end-expiratory pressure [PEEP] of 5–15 mbar) should be harnessed as early as possible (*Box 2*, ↑), since it has increasingly shown beneficial, albeit weaker effects in non-ARDS patients, too (24, 25). Semi-recumbent position proposed for the prevention or treatment of impaired pulmonary function should, however, not exceed 30 degrees in ICS patients because of the risk of hypotension. Continuous lateral rotation ("kinetic therapy") showed favorable results in ventilated patients with cardiogenic shock: lower rate of ventilation-induced pneumonia and pressure ulcers and reduction in one-year mortality (26).

For analgesia, opioid-based treatment should primarily be used (↑) and benzodiazepines should be used for long-term sedation (>72 h; mandate holder of the Austrian Society for Internal and General Intensive Care and Emergency Medicine (ÖGIAIN, *Österreichische Gesellschaft für Internistische und Allgemeine Intensivmedizin und Notfallmedizin*): from day 7) (↑), while the mandate holders of the German Society of Anesthesiology and Intensive Care Medicine (DGAI, *Deutsche Gesellschaft für Anästhesiologie und Intensivmedizin*) recommend propofol as treatment of first choice for long-term sedation, provided adequate experience. Weaning (27), which is critical especially in ICS patients, should start immediately after hemodynamic and respiratory stabilization (↑) according to a weaning protocol (↑).

Acute kidney failure

Acute kidney failure (28) should be treated with one of the two renal replacement therapies—continuous renal replacement therapy (CRRT) or intermittent hemodialysis (IHD)—(↑), whereas the mandate holders of ÖGIAIN clearly recommend the use of continuous renal replacement therapy in hemodynamically unstable ICS patients.

Cardiovascular autonomic dysfunction

ICU patients with shock, MODS and sepsis—including ICS patients—are characterized by an inadequately high heart rate (≥ 90–95/min) and restricted heart rate variability. A study reported significant heart rate reduction using esmolol, an intravenous beta blocker, in patients with septic shock, and two further studies with the pacemaker channel blocker (If blocker) ivabradin, both in MODS patients and in ICS patient (29). However, no treatment recommendation for ICS patients can be derived from these findings.

Hypoxic hepatitis, gastrointestinal dysfunction, endocrine dysfunction (CIRCI), CIP and CIM

See *eBox 2* for details.

General ICU and prophylactic measures

The two key nutritional recommendations are (*Box 2*): no nutritional support in patients with uncontrolled shock (↓) and no glutamine supplementation (↓). Blood sugar levels should be <150 mg/100 mL/<8.3 mmol/L (*Box 2*, ↑). The restrictive transfusion strategy in patients with anemia is described in *Box 2*. In ICS patients in the shock state, unfractionated heparin (10 000–15 000 I.E./24 h) should be used for thromboembolism prophylaxis and administered intravenously

(↑↑) , given the unreliability of subcutaneous (↓) absorption *(Box 2)*. The stress ulcer prophylaxis recommendation for ICS patients remains at "shall" level (*Box 2*, ↑↑), despite the skepticism about general stress ulcer prophylaxis for all ICU patients. Supplementary information about ICU and prophylactic measures in general is provided in *eBox 3*.

Recommendations for aftercare/rehabilitation

A rehabilitation program (30) shall be offered to all ICS patients (*Box 2*, ↑↑), with subsequent enrollment in a heart failure/post-ICU outpatient clinic and 6-monthly to annual follow-up examinations by one of the treating physicians.

The quality of life of ICS patients who underwent acute revascularization was rated for the majority of these patients as moderate to good, even after 6 years—this is comparable to the quality of life in the general population (31).

Discussion

Urgent need for research

Many recommendation of this clinical practice (S3) guideline are based on expert opinions, because higher grade evidence was not available.

Temporary percutaneous support devices

In no other group of myocardial infarction patients, the timing of prehospital treatment is as critical as in the group of ICS patients (1). Today, earliest possible successful revascularization of the occluded coronary vessel is achieved in more than 90% of ICS patients; thus, this component of treatment with implantation of a DES and limitation of revascularization to the "culprit lesion" (6, 7) appears to be exhausted for now. Consequently, efforts to reduce ICS mortality currently focus "only" on timely improvement of impaired cardiac output and optimization of intensive care treatment; based on the current body of evidence, little is to be expected of new inotropic and vasoactive substances. Thus, the key question is whether TMCS devices, such as Impella pumps or VA-ECMOs, with pumping capacities of up to 7 L/min are capable of increasing blood flow to vital organs timely enough to prevent the development of MODS. The small studies and meta-analyses available to date, which were not designed to evaluate mortality, are, however, not promising. This makes it all the more important to wait for the results of the initiated RCTs which are designed to assess mortality reduction. As expected—but not based on evidence—the use of VA-ECMO in Germany has increased from 500 in 2012 to 3000 in 2014 (32).

Lung-protective ventilation

Up to 80% (7, 33) of ICS patients require mechanical ventilation. The expert opinion-supported recommendation of lung-protective ventilation (*Box 2*, ↑) is based on its favorable effect—with good evidence for mortality reduction—among ARDS and sepsis patients as well as ICU patients without ARDS in need of ventilation; however, the evidence for the latter patient group is weaker (24, 25, 34). The effectiveness of lung-protective ventilation has yet to be proven in RCTs.

Weaknesses and limitations of the guideline

Only 6 of 95 recommendations are based high-quality evidence from studies. It is encouraging to note that since the first publication of this guideline two large studies—the IABP-SHOCK II study (10) and the CULPRIT-SHOCK study (7)—have provided conclusive evidence in support of two important treatments for ICS patients: the proof of lack of benefit of IABP in patients with ICS due to pump failure; and the recommendation to primarily only treat the "culprit lesion" using pPCI in patients with multivessel coronary artery disease (*Box 2*).

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Conflict of interest

Prof. Werdan received fees for his function as Chairman of the Heart Failure Think Tank of Novartis. He is a research associate of a preclinical, BMBF-sponsored research project on the development of a cardiac support system.

Prof. Buerke received fees for his participation in the scientific advisory board of Boehringer Ingelheim. He maintains personal relationships related to the subject and received lecture fees from Orion, Abiomed, Draeger, AstraZeneca, Daichi, Novartis, Bayer, Boehringer Ingelheim, and Pfizer.

Univ.-Doz. Dr. Geppert received lecture fees from Maquet and Abiomed.

Dr. Ruß received authorship/co-authorship fees for a publication related to the topic from Elsevier.

Prof. Thiele and Prof. Zwissler declare no conflict of interest.

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Clinical guidelines are not peer-reviewed in Deutsches Ärzteblatt, as well as in many other journals, because clinical (S3) guidelines are texts which have already been repeatedly evaluated, discussed and broadly consented by experts (peers).

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References

1. Scholz KH, Maier SKG, Maier LS, et al.: Impact of treatment delay on mortality in ST-segment elevation myocardial infarction (STEMI) patients presenting with and without haemodynamic instability: results from the German prospective, multicentre FITT-STEMI trial. Eur Heart J 2018; 39: 1065–74.
2. Werdan K, Ruß M, Buerke M, Delle-Karth G, Geppert A, Schöndube FA: Cardiogenic shock due to myocardial infarction: diagnosis, monitoring and treatment. A German-Austrian S3 guideline. Dtsch Arztebl Int 2012; 109: 343–51.
3. Zeymer U, Bueno H, Granger CB, et al.: Acute Cardiovascular Care Association position statement for the diagnosis and treatment of patients with acute myocardial infarction complicated by cardiogenic shock: a document of the Acute Cardiovascular Care Association of the European Society of Cardiology. EHJ Acute Cardiovasc Care 2020; 9: 183–97.
4. Werdan K, Ruß M, Boeken U, et al: Infarkt-bedingter kardiogener Schock – Diagnose, Monitoring und Therapie. S3-Leitlinie. AWMF-RN 019–013. AWMF 2019. /www.awmf.org/leitlinien/detail/ll/019–013.html (last accessed on 28 December 2020).
5. Thiele H, Ohman EM, de Waha-Thiele S, et al.: Management of cardiogenic shock complicating myocardial infarction: an update 2019. Eur Heart J 2019; 40: 2671–83.
6. Bangalore S, Gupta N, Guo Y, et al.: Outcomes with invasive vs. conservative management of cardiogenic shock complicating acute myocardial infarction. Am J Med 2015; 128: 601–8.

7. Thiele H, Akin I, Sandri M, et al.: PCI strategies in patients with acute myocardial infarction and cardiogenic shock. N Engl J Med 2017; 377: 2419–32.
8. White HD, Assmann SF, Sanborn TA, et al.: Comparison of percutaneous coronary intervention and coronary artery bypass grafting after acute myocardial infarction complicated by cardiogenic shock: results from the should we emergently revascularize occluded coronaries for cardiogenic shock (SHOCK) trial. Circulation 2005; 112: 1992–2001.
9. Zeymer U, Hochadel M, Karcher A-K, et al.: Procedural success rates and mortality in elderly patients with percutaneous coronary intervention for cardiogenic shock. JACC Cardiovasc Interv 2019; 12: 1853–9.
10. Thiele H, Zeymer U, Neumann F-J, et al., for the IABP-SHOCK II Trial Investigators: Intraaortic balloon support for myocardial infarction with cardiogenic shock. N Engl J Med 2012; 367: 1287–96.
11. Zeymer U, Schneider S, Zahn R, et al.: Impact of pre-hospital resuscitation on short- and long-term mortality in patients with cardiogenic shock undergoing revascularization: results of IABP-SHOCK study. J Am Coll Cardiol 2018; 71 (11 Suppl): 198 Presentation Number 1262–456.
12. Michels G, Wengenmayer T, Hagl C, et al.: Empfehlungen zur extrakorporalen kardiopulmonalen Reanimation (eCPR): Konsensuspapier der DGIIN, DGK, DGTHG, DGfK, DGNI, DGAI, DIVI und GRC. Med Klin Intensivmed Notfmed 2018; 113: 478–86.
13. Pichler P, Antretter H, Dünser M, et al.: Positionspapier der Österreichischen Kardiologischen Gesellschaft zum Einsatz der extrakorporalen Membranoxygenation (ECMO) bei Erwachsenen kardiologischen Patienten. Wien Klin Wochenschr 2015; 127: 169–84.
14. Levy B, Clere-Jehl R, Legras A, et al.: Epinephrine versus norepinephrine for cardiogenic shock after acute myocardial infarction. J Am Coll Cardiol 2018; 72: 173–82.
15. Prondzinsky R, Lemm H, Swyter M, et al.: Intra-aortic balloon counterpulsation in patients with acute myocardial infarction complicated by cardiogenic shock: the prospective, randomized IABP SHOCK trial for attenuation of multiorgan dysfunction syndrome. Crit Care Med 2010; 38: 152–60.
16. Prondzinsky R, Unverzagt S, Russ M, et al.: Hemodynamic effects of intra-aortic balloon counterpulsation in patients with acute myocardial infarction complicated by cardiogenic shock: the prospective, randomized IABP SHOCK trial. Shock 2012; 37: 378–84.
17. Unverzagt S, Buerke M, de Waha A, et al.: Intra-aortic balloon pump counter-pulsation (IABP) for myocardial infarction complicated by cardiogenic shock. Cochrane Database Syst Rev 2015; 3: CD007398.
18. Schrage B, Ibrahim K, Loehn T, et al.: Impella support for acute myocardial infarction complicated by cardiogenic shock: a matched-pair IABP-SHOCK II trial 30-day mortality analysis. Circulation 2019; 139: 1249–58.
19. Thiele H, Jobs A, Ouweneel DM, et al.: Percutaneous short-term active mechanical support devices in cardiogenic shock: a systematic review and collaborative meta-analysis of randomized trials. Eur Heart J 2017; 38: 3523–31.
20. Tramm R, Ilic D, Davies AR, et al.: Extracorporeal membrane oxygenation for critically ill adults. Cochrane Database Syst Rev 2015; 1: CD010381.
21. Ouweneel DM, Schotborgh JV, Limpens J, et al.: Extracorporeal life support during cardiac arrest and cardiogenic shock: a systematic review and meta-analysis. Intensive Care Med 2016; 42: 1922–34.
22. Formica F, Mariani S, D'Alessanmdro S: Acute mechanical complications in patients suffering from acute myocardial infarction. Vessels Plus 2019; 3: 37.
23. Schlotter F, de Waha S, Eitel I, et al.: Interventional post-myocardial infarction ventricular septal defect closure: a systematic review of current evidence. EuroIntervention 2016; 12: 94–102.
24. Adamzik M, Bauer A, Bein T, et al.: Invasive Beatmung und Einsatz extrakorporaler Verfahren bei akuter respiratorischer Insuffizienz. S3-Leitlinie. AWMF-RN 001/021. 1th edition. Stand 05.12.2017. www.awmf.org/uploads/tx_szleitlinien/001–021l_S3_Invasive_Beatmung_2017–12.pdf (last accessed on 30 December 2020).
25. Guo L, Wang W, Zhao N, et al.: Mechanical ventilation strategies for intensive care unit patients without acute lung injury or acute respiratory distress syndrome: a systematic review and network meta-analysis. Crit Care 2016; 20: 226.
26. Simonis G, Steiding K, Schaefer K, et al.: A prospective, randomized trial of continuous lateral rotation ("kinetic therapy") in patients with cardiogenic shock. Clin Res Cardiol 2012; 101: 955–62.
27. Dres M, Teboul JL, Monnet X: Weaning the cardiac patient from mechanical ventilation. Curr Opin Crit Care 2014; 20: 493–8.
28. Lauridsen MD, Gammelager H, Schmidt M, et al.: Acute kidney injury treated with renal replacement therapy and 5-year mortality after myocardial infarction-related cardiogenic shock: a nationwide population-based cohort study. Crit Care 2015; 19: 452.
29. Barilla F, Pannarale G, Torromeo C, et al.: Ivabradine in patients with ST-elevation myocardial infarction complicated by cardiogenic shock: a preliminary randomized prospective study. Clin Drug Investig 2016; 36: 849–56.
30. Bjarnason-Wehrens B, Held K, Hoberg E, et al.: Deutsche Leitlinie zur Rehabilitation von Patienten mit Herz-Kreislauferkrankungen (DLL-KardReha). Clin Res Cardiol Supplements 2007; 2: III/1-III/54. Aktualisierung: S3–Leitlinie zur kardiologischen Rehabilitation (LL-KardReha) im deutschsprachigen Raum Europas. Deutschland, Österreich, Schweiz (D-A-CH), Langversion – Teil 1, 2019 AWMF-RN: 133/001, www.awmf.org/uploads/tx_szleitlinien/133–001k_S3-Kardiologische-Rehabilitation-in-D-A-CH_2020–12.pdf (last accessed on 12 December 2020).
31. Thiele H, Zeymer U, Thelemann N, et al.: Intraaortic balloon pump in cardiogenic shock complicating acute myocardial infarction: long-term 6-year outcome of the randomized IABP-SHOCK II trial. Circulation 2019; 139: 395–403.
32. Karagiannidis C, Windisch W: Epidemiologie und Mortalität der Herz- und Lungenersatzverfahren in Deutschland zwischen 2007 und 2014. (Letter). Med Klin Intensivmed Notfmed 2016; 111: 556–9.
33. Van Diepen S, Hochman JS, Stebbins A, et al.: Association between delays in mechanical ventilation initiation and mortality in patients with refractory cardiogenic shock. JAMA Cardiol 2020; 5: 965–7
34. Schneck M, Hoder K, Gielen S, et al.: Lung protective ventilation and hospital survival of cardiac intensive care patients. Med Klin Intensivmed Notfmed 2016; 111: 508–13.
35. Reintam Blaser A, Malbrain ML, Starkopf J, et al.: Gastrointestinal function in intensive care patients: terminology, definitions and management. Recommendations of the ESICM Working Group on Abdominal Problems. Intensive Care Med 2012; 38: 384–94.
36. Werdan K, Boeken U, Briegel J, et al.: Infarktbedingter kardiogener Schock – Diagnose, Monitoring und Therapie. S3-Leitlinie. Intensiv- und Notfallbehandlung 2021; 46, in print.
37. Reignier J, Boisramé-Helms J, Brisard L, et al.: Enteral versus parenteral early nutrition in ventilated adults with shock: a randomised, controlled, multicentre, open-label, parallel-group study (NUTRIREA-2). Lancet 2018; 391: 133–43.
38. Heyland D, Muscedere J, Wischmeyer PE, et al.: A randomized trial of glutamine and antioxidants in critically ill patients. N Engl J Med 2013; 368: 1489–97.
39. The PEPTIC Investigators for the Australian and New Zealnad Intensive Care Society Clinical Trials Group. Alberta Health Services Critical Care Strategic Clinical Network, and the Irish Critical Care Trials Group: Effect of stress ulcer prophylaxis with proton pump inhibitors vs histamine-2 receptor blockers on in-hospital mortality among ICU patients receiving invasive mechanical ventilation. The PEPTIC Randomized Clinical Trial. JAMA 2020; 323: 616–26.

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► **Supplementary material**

eFigure and eBoxes:
www.aerzteblatt-international.de/m2021.0012

Supplementary material to:

Infarction-related Cardiogenic Shock – Diagnosis, Monitoring and Therapy

A German-Austrian S3 guideline

by Karl Werdan, Michael Buerke, Alexander Geppert, Holger Thiele, Bernd Zwissler, and Martin Ruß, on behalf of the guideline group

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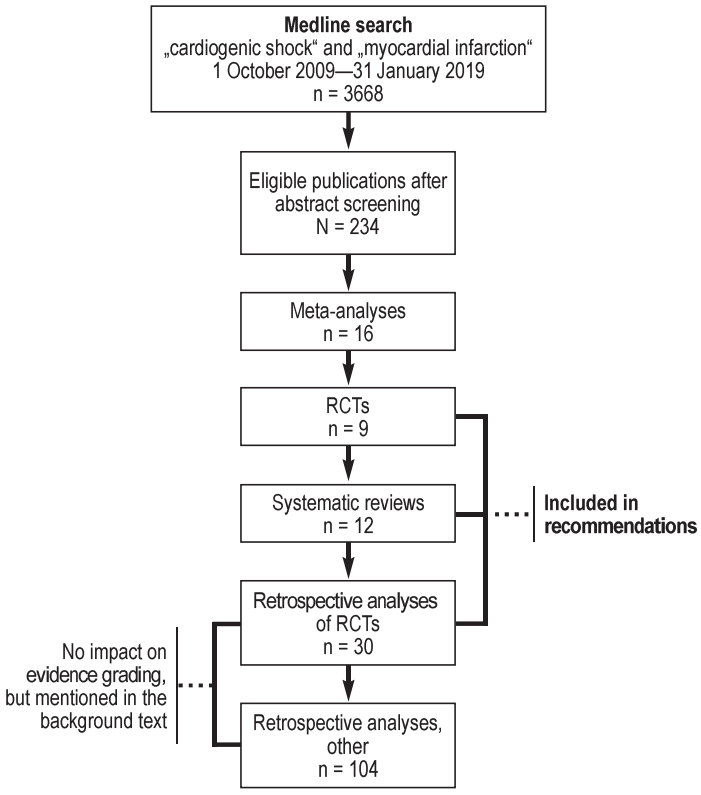
eFIGURE



Literature search and selection for clinical practice (S3) guideline
“Infarction-related Cardiogenic Shock Diagnosis, Monitoring and Therapy”(4)
RCT, randomized controlled trial

eBOX 1

Composition of the guideline group (collaborators)

- **Mandate holders of the medical societies**

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- **Moderation according to AWMF rules for Guidelines**

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Institute for Medical Knowledge Management (IMWI, Institut für Medizinisches Wissensmanagement) of the Association of Scientific Medical Societies in Germany (AWMF, Arbeitsgemeinschaft der Wissenschaftlichen Medizinischen Fachgesellschaften)

- **Participating medical societies**
  - German Society of Internal Intensive Care and Emergency Medicine (DGIIN, Deutsche Gesellschaft für Internistische Intensivmedizin und Notfallmedizin)
  - German Society for Thoracic and Cardiovascular Surgery (DGTHG, Deutsche Gesellschaft für Thorax-, Herz- und Gefäßchirurgie)
  - German Society of Anesthesiology and Intensive Care Medicine (DGAI, Deutsche Gesellschaft für Anästhesiologie und Intensivmedizin)
  - Austrian Society for Internal and General Intensive Care and Emergency Medicine (ÖGIAIN, Österreichische Gesellschaft für Internistische und Allgemeine Intensivmedizin und Notfallmedizin)
  - Austrian Society of Cardiology (ÖKG, Österreichische Kardiologische Gesellschaft)
  - German Society of Cardiovascular Prevention & Rehabilitation (DGPR, Deutsche Gesellschaft für Prävention und Rehabilitation von Herz-Kreislauf-Erkrankungen)
  - German Interdisciplinary Association for Intensive Care Medicine and Emergency Medicine (DIVI, Deutsche Interdisziplinäre Vereinigung für Intensiv- und Notfallmedizin)

  - Leading:
    German Cardiac Society (DGK, Deutsche Gesellschaft für Kardiologie – Herz- und Kreislaufforschung)

eBOX 2

Supplementary material: Management of organ dysfunction

- **Hypoxic hepatitis**
  - Definition in ICU patients:
    ≥ 20-fold increase in aminotransferase levels
  - Prognosis of ICU patients:
    Increased 30-day mortality (68% versus 34%; p<0.001)
  - Management of ICU patients:
    Improvement of shock-related signs and symptoms, avoidance of hepatotoxic medications and replacement of clotting factors, where needed

- **Gastrointestinal dysfunction (GIF/AGI)** (35)
  - Incidence in ICU patients:
    very common, to varying degrees
  - Management of ICU patients:
    Treatment according to stage, see e.g. Fig. 1 in (35)
    und Fig. 9.4.I in (4, long version)

- **Endocrine dysfunction: CIR**CI
  - Relevant in septic shock, after cardiac surgery and in ROSC patients
  - Based on current knowledge, CIRCI it does not play a role in ICS; consequently, no administration of hydrocortisone required

- **Critical illness polyneuropathy and critical illness myopathy**
  - Relevant for all ICU patient populations, thus also for ICS patients
  - To date, no causal treatment available
  - Supportive treatment: Treatment of MODS, optimum nutrition, physiotherapy, therapeutic exercise and early mobilization

Detailed information in (4, 36)

AGI, acute gastrointestinal injury; CIRCI, critical illness-related corticosteroid insufficiency; GIF, gastrointestinal failure; ICS, infarction-related cardiogenic shock; ICU, intensive care unit; MODS, multiple organ dysfunction syndrome; ROSC, return of spontaneous circulation

eBOX 3

Supplementary material: General ICU and prophylactic measures

- Nutrition
  - In ICS patients, enteral nutrition should be preferred to parenteral nutrition (↑); the latter only in patients with normal nutritional status after 7 to 10 days, if calorie and protein intake >60% cannot be achieved with enteral nutrition (↑).
  - Hemodynamic shock instability is associated with a risk of ischemia- and reperfusion-related damage to gastrointestinal microcirculation.
  - Early enteral nutrition in ventilated shock patients does not reduce mortality, but leads to gastrointestinal complications (37). Consequently, enteral nutrition should not be given to ICS patients with uncontrolled shock (MAP<50 mm Hg, persistent lactic acidosis without normalization tendency and/or norepinephrine doses >1 µg/kg/min or increasing catecholamine requirement) before shock control has been achieved (Box 2, ↓); only *after shock* stabilization, low-dose enteral trophic nutrition ("intestinal villi nutrition") should be started.
  - No enteral or parenteral glutamine supplementation (*Box 2*, ↓): In the REDOXS study (38) on ventilated MODS patients—20% of these with cardiogenic shock—, glutamine supplementation was associated with significantly increased in-hospital mortality (37.2% versus 31.0%; p = 0.02) and 6-month mortality (43.7% versus 37.2%; p = 0.02).

- **Blood sugar control**
  - With this recommendation (< 150 mg/100 mL/ < 8.3 mmol/L, *Box 2*, ↑), on the one hand, the increased mortality associated with high blood sugar levels and, on the other hand, the risk of hypoglycemia have to be balanced.
  - ICS patients (both with and without diabetes mellitus) with admission blood sugar levels above the median concentration (11.5 mmol/L/207 mg/100 mL) had an increased 30-day mortality (47.7% versus 36.5%; p = 0.004) und 1-year mortality (57.7 versus 47.1%; p = 0.011) compared to ICS patients with lower than median blood sugar levels.

- **Transfusion strategy**
  - Severe anemia: Hb<8.0 g/100 mL/<5.0 mmol/L
  - Restrictive instead of liberal transfusion strategy: In the absence of data from studies with a special focus on ICS patients, the available evidence from ICU patients and, above all, from myocardial infarction patients and cardiac surgery patients suggests that a rather restrictive (Hb 7.0 g/100 mL/4.3 mmol/L) transfusion strategy is superior to a more liberal one (Hb 9.0 g/100 mL/5.6 mmol/L) (*Box 2*, ↑).
  - The risk of transfusion-associated circulatory overload—observed in one in twenty transfused ICU patients—is especially common among ICS patients.

- **Thromboembolism prophylaxis**
  - No subcutaneous (↓), but continuous intravenous thromboembolism prophylaxis (↑↑) during the shock state *(Box 2)*, since subcutaneous absorption of heparin is unreliable in the acute shock state.
  - At the time venous thromboembolism prophylaxis (↑↑) is started, the ICS patient is already anticoagulated with intravenous unfractionated heparin administered during the pPCI treatment. Thus, subsequent prophylaxis with unfractionated heparin at a dose of 5000 IU every 8 h or 12h, or at a dose of 7500 IU every 12 h, is worthwhile strategy, at least as long as the shock state persists.

- **Stress ulcer prophylaxis**
  - Currently: Skepticism about the usefulness of general stress ulcer prophylaxis in all ICU patients, since the available evidence, while supporting a reduction in gastrointestinal bleeding, does not show a reduction in mortality.
  - The ICS patient is a high-risk patient for gastrointestinal bleeding! ICS patients shall therefore receive stress ulcer prophylaxis (*Box 2*, ↑↑).
  - Lower incidence of gastrointestinal bleeding in patients treated with proton pump inhibitors compared with patients treated with H2 receptor antagonists (39)

Detailed information in (4, 36).
Hb, hemoglobin; ICS, infarction-related cardiogenic shock; ICU, intensive care unit; MAP, mean arterial pressure; MODS, multiple organ dysfunction syndrome; pPCI, primary percutaneous coronary intervention

Questions on the article in issue 6/2021:

Idiopathic Facial Pain Syndromes—An Overview and Clinical Implications

cme plus

CME credits for this unit can be obtained via cme.aerzteblatt.de until 11 February 2021.
Only one answer is possible per question. Please select the answer that is most appropriate.

Question 1

The characterization of 411 facial pain patients of the Headache and Facial Pain Outpatient Clinic of the University Medical Center Hamburg-Eppendorf included information about which doctors had previously been consulted by the patient for facial pain. Which statement about consultation of doctors is correct?

a) The general practitioner is never consulted.
b) Pain therapists are hardly ever consulted.
c) Patients with facial pain initially see a dentist, but do consult many other disciplines as well
d) Consultation of an ENT specialist is extremely rare.
e) Patients with facial pain only consult dentists.

Question 2

What is a typical symptom description of persistent idiopathic facial pain?

a) The pain is most severe at night as sleep is disrupted by the attacks.
b) During the daytime, the pain fluctuates without any concomitant symptoms or sensory negative symptoms.
c) The pain is most severe on waking and its intensity significantly decreases over the day.
d) The pain fluctuates over the day and hypoesthesia increases during the course of the day.
e) Pain which can be triggered by touch and is increased by eating or drinking.

Question 3

What interventions should be avoided in the management of persistent idiopathic facial pain?

a) Early involvement of specialists in pain psychology in the management of the patient
b) Administration of antidepressants
c) Administration of anticonvulsants
d) Combination therapies (antidepressant + anticonvulsant)
e) Dental interventions

Question 4

In what percentage range is the lifetime prevalence of trigeminal neuralgia estimated to be?

a) 0.3%
b) 1.6%
c) 3.2%
d) 4.5%
e) 5.2%

Question 5

To which medication do up to 90% of patients with trigeminal neuralgia initially respond?

a) Calcium channel blockers: gabapentin
b) Sodium channel blockers: lamotrigine
c) Local anesthetics: lidocaine
d) Sodium-channel blockers: carbamazepine
e) Hydantoin derivatives: phenytoin

Question 6

The International Classification of Orofacial Pain (ICOP) classifies trigeminal neuralgia into three subgroups. What are these three subgroups?

a) Classical TN, idiopathic TN, secondary TN
b) Primary TN, secondary TN, tertiary TN
c) Idiopathic TN, secondary TN, atypical TN
d) Idiopathic TN, secondary TN, tertiary TN
e) Primary TN, idiopathic TN, atypical TN

Question 7

For what type of headache are triptans used as a component of treatment?

a) Paroxysmal hemicrania
b) Neuropathic facial pain
c) Facial migraine
d) Trigeminal neuralgia
e) Atypical facial pain (PIFP)

Question 8

What clinical signs and symptoms are typical for facial migraine?

a) Attacks of 2–30 minutes, unilateral, lacrimation
b) Attacks of 15–180 minutes, triggerable, aura
c) Attacks of 2–30 minutes, triggerable by touch, eating/drinking
d) Attacks of 15–180 minutes, unilateral, sweating
e) Attacks of 4–72 hours, sensitivity to light/noise, nausea

Question 9

What diagnosis was most common in the characterization of 411 facial pain patients of the Headache and Facial Pain Outpatient Clinic of the University Medical Center Hamburg-Eppendorf?

a) Trigeminal neuralgia
b) Neuropathic facial pain
c) Migraine
d) Persistent idiopathic facial pain (PIFP)
e) Paroxysmal hemicrania

Question 10

Patients reporting of continuous burning facial and also hypoesthesia in the same area do most likely suffer from which type of facial pain?

a) Facial migraine
b) Facial cluster headache
c) Neuropathic facial pain
d) Persistent idiopathic facial pain (PIFP)
e) Psychogenic facial pain